Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

31st, cap. 10; 35th, cap. 7; and made perpetual by the 39th, cap. 18, of the same reign.[1]

The period when the practice of taking interest was finally authorized by law in England is an appropriate one for closing the first division of the subject, upon which I trust that some light, however imperfect, may have been thrown by the facts I have been enabled to collect.

(End of Part I.)

Some Suggestions respecting Fire Insurance Statistics. By Thomas Miller, *Esq., of the Scottish Union Insurance Society, London.*

[Read before the Institute, 29th December, 1856, and ordered by the Council to be printed.]

THE efforts made by Fire Insurance Companies to collect accurate particulars of the state of their business, and the profit or loss on different classes of risks, evince at once their appreciation of correct statistical information and the difficulty of obtaining it. Most Offices of any standing keep registers in which risks are divided into distinct classes—such as cotton mills, corn mills, farm stock, dwelling-houses, carpenters' shops, &c. &c.; and in one set enter under their proper heads the sums insured, premiums received, and number of risks, so that they can tell from inspection how many corn or cotton mills, or other risks, they insure each year, the total sums insured on them, and the amounts of premiums received: while in another set they enter under their proper heads the number of corn or cotton mills, or other risks, in which loss has occurred, and the losses paid—so that by inspection they can see what losses have been sustained on each class. The difference between the premiums received and the losses paid, leaving expenses of management out of view, constitutes a surplus or deficiency from which they judge of the profit or loss on each class of their insurances.

One distinct objection exists to the common statistics—namely, that from the form in which they are made, their correctness cannot be entirely trusted, as the hazard of a class of risk is estimated not solely by the proportion of loss which occurs, but also by the amounts which happen to be insured on the properties on which loss is sustained.

[1] *Statutes of the Realm* iv. 917.

In proof of this, suppose an Office, A, to insure 25 cotton mills for the following sums:—Nos. 1 to 15 for £2,500 each, and Nos. 16 to 25 for £5,000 each; and another Office, B, to insure the same mills—Nos. 1 to 10 for £5,000 each, and 11 to 25 for £2,500 each; total sum insured, and premium, being alike in both cases.

If Nos. 2 and 9 be destroyed, then Office A will lose £2,500 and £2,500 = £5,000; and Office B, £5,000 and £5,000 = £10,000: and according to the common mode of interpreting these figures, B's "experience" of cotton mills is twice as bad as A's; as, with the same amount of premium received, double the loss has been sustained.

The true statistics of loss on these 25 cotton mills are in reality the very same in both cases—the same total premium for their insurance having been paid to each Company, the losses having occurred by destruction of the same mills, and the amounts paid by each Company being in the same proportions to the sums respectively insured by them on the two mills. The difference which appears arises entirely from the accidental circumstance of the one Office having in the particular cases insured double the amounts covered by the other; and had the losses occurred on mills 11 and 14, or on mills 17 and 24, the "experience" of the two Companies would in the former case have been exactly alike, and in the latter exactly reversed. It is evident, therefore, that full reliance cannot be placed on a merely debtor and creditor account of premiums and losses, and that the surplus or deficiency, although it may prove a profit or loss to have occurred, does not necessarily afford a sufficient guide for future transactions.

The reason of this is, that the losses have been judged of by different measures—those under A's policies, by the measure of £2,500 insured in each case, and those under B's by that of £5,000 insured by it on each of the mills. Similarly, losses may happen where one Office pays £5,000 and another £500, the measure of loss to the former being ten times as great as that to the latter; or the same Office may lose £3,000 on property which had until recently been insured only for £1,000; so that the accident of an increased sum being insured before the fire happened makes a different measure to be applied to the extent of its ravages.

As the object of collecting fire insurance statistics is not merely to know how events have turned out during the past, in order that profit or loss may be apportioned to each class of risk, but to ascer-

tain how far past experience may be used to guide future practice, some method seems necessary by which the same event shall have a uniform expression, and not one dependent upon accidental circumstances, which do not generally show its real bearings. Reverting to the example already given, it appears that, to obtain uniform expressions for the same events, it is requisite that a known quantity be constituted a measure of them all; so that each risk must be considered insured for the very same amount. In general, unity is the best standard for practical operations; but where the premium, compared with the sum insured, is so small as in fire insurance, perhaps 100 would be a more suitable one.

In reducing to this measure the process is simple. The sum insured will always be considered £100, so that the premium will just be the rate per cent.; and it may either be expressed as a decimal or in the ordinary way. The loss per cent. may be found by the proportion—as the actual sum insured : is to £100 : : so is the loss paid : to the loss per cent.

Assuming for the present that a proper classification of risks exists, the plan may be considered by which data may most readily be collected. The books in general use for this purpose are two—namely, a Register of Insurances, and a Register of Losses. To these may be added a third, showing an Abstract of premiums and losses contrasted with each other.

The "Register of Insurances" contains the following particulars:—A heading, which may be written across at any place, specifying the class of risk and its number; and, in perpendicular columns, 1, The agency. 2, The name of person insured. 3, The situation and name of risk. 4, The policy number. 5, Quarter when due. 6, A column marked "Year 18—," and subdivided into columns consisting of the sum insured, number of risks, and premium. 7, If renewed or cancelled next year, "R" or "C." 8, 9, 10, 11, 12, &c., Repetitions of 6 and 7 as often as desirable, or as the size of the book will admit.

The "Register of Losses" contains a similar heading to that of premiums, and the following particulars in perpendicular columns:—1, The agency. 2, The name of person insured. 3, The situation and name of risk. 4, The policy number. 5, The sum insured. 6, The number of risks. 7, The loss paid.

The "Abstract" consists of perpendicular columns, arranged thus:—

Year.	Class No. —, *and space for name of risk.*						Class No. —, &c.
	Total Sum insured.	No. of Risks.	Premium.	Losses.			&c.
				Sums insured.	No. of Risks.	Loss paid.	
18— 18— 18—							&c.

As many classes may be placed side by side as the size of the book will admit.

Such books contain all the particulars usually collected by Insurance Companies; but to obtain a uniform expression for the same event, and the statistics of loss on each class of risk, so that they may be interpreted correctly, the process already pointed out may be effected in the following way:—

A book will be required, called the "REGISTER OF EQUATED INSURANCE," headed "Class. No. — Name of risk," and containing, in perpendicular columns, 1, The agency. 2, Policy number. 3, Column headed for the year 18—, and subdivided into columns for the sum insured and the premium. 4, If renewed or cancelled next year, "R" or "C." 5, 6, 7, &c., Repetitions of 3 and 4 for following years. The entries in columns 1, 2, and 4, and the repetitions of the last of these, may be copied from the "Register of Insurances"; the sum insured will be £100, and the premium the rate per cent.

In connection with this book will be required a "REGISTER OF EQUATED LOSSES"; containing the heading as above, and, in perpendicular columns, 1, The agency. 2, Policy number. 3, Sums insured. 4, The equated loss. The entries in columns 1 and 2 will be a transcript of those in the "Register of Losses"; the sum insured will be £100, and the equated losses will be derived from actual losses, in the manner already noticed.

An "ABSTRACT OF EQUATED INSURANCES AND LOSSES" will also be required.

The particulars contained in these three books may respectively be incorporated with those of the Register of Insurances, the Register of Losses, and the Abstract; and if so, the labour of transcribing will be avoided.

To exhibit the advantages of the data collected in the equated form, let us refer again to the case noticed at the beginning of this article. Being equated, the sum insured by each Office on each

mill will be £100—total on the 25 mills, £2,500; and the equated losses will be £100 and £100=£200, in both cases; and as the total equated premium will also be alike in each case, the experience of the two Offices will appear, as it really should, exactly the same. So would it be if the losses were only partial instead of total, for both Offices would then pay a like sum on each £100 insured by them.

The equated system, then, supplies the form by which data receive a uniform and correct interpretation, and the following are the statistics procured through its medium for each class of risk :—

A=The total sums insured,
B=The total premium received,
C=The total sums insured on the risks where loss has occurred,
D The total loss paid,

} On the supposition that £100 is the amount insured on each risk.

The fraction $\frac{D}{A}$ shows the RATE of loss to each pound insured; and multiplied by 100, it gives the average rate per cent. at which insurances may be accepted without probable surplus or deficiency, no allowance being made for charges of management; and if a percentage be added for expenses and profit, the average rate which should be charged as premium can thus be obtained.

The fraction $\frac{D}{C}$ measures the average proportion of each loss; and by a comparison carried over a number of years, it furnishes the means of ascertaining how far losses on each class of risk increase or diminish in intensity.

$\frac{A}{C}$ = the number of risks amongst which one loss may be expected. This loss may be considered an average one.

$\left(\pm\frac{B}{A}\mp\frac{D}{A}\right)\times 100$=the average excess or deficiency of rate per cent. charged for each insurance, leaving profit and charges out of view.

It should be understood that the data of an Insurance Company in this country must differ considerably from actual statistics *of fires*—that is to say, the total amounts insured do not bear the same proportion to the losses sustained which the total value of the property in the country bears to the actual damage which occurs from fire; and if we descend to particulars, the same may be stated in reference to each individual class of risk. Were it pos-

sible to procure a statement showing the value of each risk in the country, to classify the different risks under separate heads, and also to ascertain how many fires occurred and the extent of damage in each case, and to equate the data in the manner pointed out, the results would agree with those experienced by Insurance Companies if their policies were all issued subject to the conditions of average in their integrity, and no expenses were incurred in the settlement of claims. As some readers may not understand the operation of this law, it may be explained that if a loss occur the Office will only pay that portion of it which is measured by the fraction $\frac{\text{sum insured}}{\text{value of property insured}}$; so that if the sum be £5,000 while the value of property is £10,000, the Office will only pay $\frac{5,000}{10,000}$ths, or half of the loss, the assured bearing the other half himself, if not insured in some other Office.

We may therefore practically consider that the actual statistics *of fires* would correspond with data collected under the operation of the average clause. Such data will differ from those collected under ordinary insurances—the latter representing not the real statistics *of fires,* but a compound of them and of a fluctuating quantity which follows a different law altogether. If $\frac{D}{A}$ be the rate of loss under common policies, $\frac{D^1}{A}$ may represent the rate under average policies; and as common policies must pay the full loss to the extent insured, while average policies in general only bear a share of it, the rate of the former will generally be greater and never less than that of the latter, and may be represented by $\frac{D}{A} = x\frac{D^1}{A}$, x being equal to $\frac{D}{D^1}$.

Suppose a property to be worth £1,500—

If damaged to the extent of	If insured for £1,000 by		Then $x = \frac{D}{D^1}$ is equal to
	A Common Policy, it would pay	An Average Policy, it would pay	
£.	£.	£.	£.
1,500	1,000	1,000	0
1,350	1,000	900	$1\frac{1}{9}$
1,000	1,000	$666\frac{2}{3}$	$1\frac{1}{2}$
500	500	$333\frac{1}{3}$	$1\frac{1}{2}$
150	150	100	$1\frac{1}{2}$

So that the general quantity $x = \frac{D}{D^1}$ is equal to the fraction

$\frac{\text{value of property insured}}{\text{sum insured}}$, when the loss does not exceed the sum insured; and for losses above that sum it decreases as the loss increases, and becomes zero when it is total, following the form

$$\text{loss} \times \frac{\text{sum insured}}{\text{value of property}} = \frac{\text{value of property}}{\text{loss}}.$$

Now, according as the proportions insured, compared with the value of property, are greater or less, the value $\frac{D}{D^1}$ correspondingly diminishes or increases; and as the losses exceed or do not exceed the amount insured, it assumes the form $\frac{\text{value of property}}{\text{loss}}$ or $\frac{\text{value of property}}{\text{sum insured}}$; so that in this inconstant quantity two laws are in operation.

As it may be interesting, if not advantageous, to investigate their nature, a short space may be allowed for this purpose.

Beginning with the one represented by the expression $\frac{\text{value of property}}{\text{sum insured}}$, if it could be ascertained what proportions the sums insured on different classes of risks bear to the values of property comprised in each of these classes, this law would be discovered. It is evidently one connected with the will: dependent partly upon individual appreciation of the risk run from being under-insured, and partly upon the ability to pay the premium required for insurance or to sustain a loss should one happen. Circumstances may combine to bring into action all or only some of these considerations; but if the proportion could be traced for each individual case, the law would probably be found to follow some regular course. A fire in one's neighbourhood may suggest the idea of taking out an insurance, or increasing the old one: new fire engines, low profits, trade bad, few men employed, and therefore less risk, although the stock of goods is great, may induce a reduction of insurance. In seasons when trade is dull, losses are heavy, especially on certain classes of risks, and an interpretation has been given to this fact not very flattering to the morality or honesty of those in distress. May it not however happen, that at such times one cause of it is, that people retrench even in the sums they insure, while, as suggested, their stocks are larger than usual; so that when losses do occur, they are more likely to fall heavily upon the Insurance Companies than at other

times, the proportion $\frac{\text{value of property}}{\text{sum insured}}$ being in general greater then than in periods of prosperity? But as it happens that the *values* of property insured cannot be ascertained, there is no direct means of solving this question, although the truth of the position may be confirmed or disproved by ascertaining the *intensity* of loss, which is measured by the fraction $\frac{D}{C}$. Some of the larger Offices have probably abundant data for determining the question; and as practical remedies are suggested by the knowledge of actual facts, the trouble of making the investigation might not be thrown away.

The second law, which is expressed by the fraction $\frac{\text{value of property}}{\text{loss}}$, is entirely a physical one. It depends altogether upon the amount of loss compared with the value of the property, and that again rests upon physical causes. If fire be discovered at the outset, it may be extinguished with little trouble: but it may be long before it be discovered; or, when it is, water may be scarce, the engines out of order, the seat of the fire difficult to reach, or the materials which feed the flames highly combustible. Some of these, or other causes, probably enter into combination in all fires of any magnitude; and although it would be impossible to classify the extreme variety of circumstances in which fires occur, or to learn the value of all property insured, yet, by observing how fires originate and from what causes they spread, and by arranging insurances into corresponding divisions with sub-divisions into classes, according to the peculiarities of risks, some of the principal physical laws of fires might be so well defined that their values could be fixed, if not with mathematical exactness, at least with something approaching to it; and while such information would guide the Offices to some extent in the selection of insurances, it would afford the surveyors of risks the means of knowing to what circumstances their inquiries should be directed.

The data collected under the equated system will supply the means of fixing the average premium which should be charged for assurances in any class of risk, but they will not show to what extent the hazard of one property of the same class differs from that of another. Suppose, for example, a house consists of one floor, occupied by one family, then there will be a certain risk of fire occurring and spreading; if another floor were added, and inhabited by a second family, the risk of fire would evidently be doubled; and could a thousand of such houses, each occupied by

one family, be placed side by side and over each other, so as to form a cube, with free communications between the whole, the risk of fire would be nearly a thousandfold as great as that of the single house of one floor. It is said that theatres, on an average, last 40 years before being destroyed by fire. If it were possible to form forty of such risks, all inter-communicating into a vast cubic structure, then within a year or little more a fire would occur amongst them, which, in the ordinary course of events, would destroy the individual theatre in which it originated; but as, on the supposition now made, that theatre would form part of an enormous erection, if it were impossible to extinguish the fire when confined to the single building, there would be no chance whatever of arresting its progress or preventing the others being entirely destroyed. The equivalent premium for the insurance would thus be nearly 100 per cent. per annum.

From this conclusion the inference is obvious, that when all the elements of hazard advance in the same ratio as extent, the relative risk of different buildings of the same kind must be measured by their size; but the extent of risk or size does not depend altogether upon their *capacity*, for often a lofty floor contains less hazard than one much lower. *In general*, it would be more correct to say that extent of risk depends more upon the superficies of the floors than upon cubic measure, for this reason—that the number of workmen and processes generally increase in proportion to the superficial, not the cubic measure. Suppose a building of six floors to be thirty yards long, twenty wide, and twenty high, its cubic measure would be $30 \times 20 \times 20 = 12{,}000$ cubic yards, and its superficial measure $30 \times 20 \times 6 = 3{,}600$ superficial yards; and it is in the latter sense that extent is understood when referred to in this paper.

To apply the principle now enunciated to practice, some addition to the equated statistics is necessary, especially in regard to mills, wholesale warehouses, and othere xtensive risks. It would not be very difficult to get returns of the superficies or extent of such risks, and the number of hands usually employed in them, and from these the average size of each and the average number of hands to the 100 superficial yards could be found. The average-sized building, with the average number of hands to the 100 superficial yards, should then form the standard for which the average rate should be charged, while those in excess or below that standard should be charged at a comparatively higher or lower rate.

It is so far advantageous to be able to determine a point such as this; but in risks of the same class there are many other gra-

dations of hazard, the values of which can only be discovered by a careful analysis of physical laws of fires. In cotton mills, for instance, the processes differ; so do the modes of heating and lighting; there are differences in the quality of cotton spun, and in the proportion of hands employed; and while, for these, differences of rate must be made, such differences, until data are collected, can only be of an arbitrary character.

The equated losses furnish the means of solving the important practical question—what sum is the maximum which should be insured on any class of risk? The process may be accomplished thus. Suppose the equated losses to be £15, £25, and £50=£90; then the average loss will be £30, the sum insured by each policy being £100. Taking the average of actual losses, which may be called y, the following proportion is obtained:—30 : y :: 100 : $3\frac{1}{3}y$=the *average sum* which should be insured by each policy to give these losses. Multiplying by the number of insurances, the product will be the *total sum* which should be insured to give these losses; but as loss *may* be sustained, equal to the premium, less charges of management, without the Office being actually a loser, it follows that such an amount *may* be added to the losses as will bring them to that point. Suppose in this case the sum to be added is 20 per cent., then the proportion will take the following form:—30 : $1\frac{1}{5}y$ :: 100 : $4y$=the sum which may be insured by each policy; so that the actual losses shall be 20 per cent. greater than formerly. This amount, multiplied by the number of insurances, will give the total sum which may be insured if the losses are to be 20 per cent. in excess of previous losses.

The next thing is to ascertain in what manner that total sum should be divided. For this purpose arrange existing insurances in order, according to the amounts insured; and, beginning with the smallest, resolve them into divisions each consisting of $\frac{A}{C}$ insurances. Take the total sum insured by each division, and observe the difference between it and the previous one, so that the rule of increase may be discovered; next adding together the amounts of the various divisions, beginning with the lowest, until the aggregate is equal to the total sum required; continuing the process according to the rule of increase when actual facts are wanting: then the average of the last of the divisions required to make up the total is the maximum which *may* be taken on any one risk with little probability of loss exceeding the premium received, less the charges of management. Should the Office be able to fill

up the blanks in the number of risks embraced in the larger divisions of insurances, the probability alluded to would of course decrease, as the corresponding increase of premium would form a fund to meet the liability. It is evident, too, that as business increases a larger maximum may be assumed, and that the amount of such maximum depends upon the profit arising from the insurance of such classes of risks.

In few classes of insurances will the experience of one year determine the amount of risk incurred; but this may be ascertained with sufficient exactness, in most instances, by grouping the results for several consecutive years. Thus, by taking those for the five years commencing respectively with the first, second, third, &c. years, and contrasting the premiums and losses, a continuous series of facts may be tabulated. This system has the advantage of showing how many years are required to produce average results; for if those collected in five years are found insufficient, the period may be extended to seven, eight, or ten years. The average premium required to yield stated profits may thus be more certainly determined than by any other plan.

The form in which the equated statistics are collected supposes the existence of each insurance for a year exactly. When the time is longer or shorter, any difficulty may be obviated by making the sum insured and the premium vary according to the time. Thus, if one insurance of £100 be for a year and a quarter, at the annual premium of £1, and another for nine months at the same annual premium, then the premium and the sum insured will in the former case be put down as £1. 5*s.* and £125, and in the latter as 15*s.* and £75 respectively. Losses, however, should always be stated as proportioned to £100 insured. When there are more than one policy in force at the same time on the same risk, care should be taken that only one of them should be entered in the Register of Equated Insurances, and only one loss appear amongst the equated losses. It may be questioned whether the entries in the Registers should distinguish between buildings and contents, but any slight advantage to be gained by such practice would probably be counterbalanced by the labour consequent upon it. Besides, there are unsettled points in the practice of insurance, such as different rules being adopted in apportioning claims under non-current policies, so that absolute correctness is not to be expected in any data which may be procured. Equated statistics, however, reduce errors to their minimum.

There are buildings termed "fire proof," which, as risks, are

greatly superior to those of ordinary construction; but the number of them being comparatively limited, it would perhaps be sufficient to treat them as one class of risk until information were collected from which certain statistics might be derived.

The application of the average clause in practice presents so many anomalies and contradictions, that the data derived from insurances under its operation differ widely from those which would be obtained were the principle of average carried out in its integrity. Many insurances are, however, effected subject to the average clause, especially upon goods in mercantile warehouses; and these might with propriety be arranged in classes, as the data respecting them must yield pretty conclusive results.

Hitherto the Offices have been contented with a very rough estimate of the risks incurred and the premiums which should be charged; and it is doubtful whether, since fire insurance was established as a business, any real advancement has been made in the methods of procuring statistics. Those which are derived from sources foreign to the Office records have little value for an Insurance Company, as they cannot give the means for *comparing* the number of risks with the value of property and the actual damage which occurs. But as the basis upon which the business is founded is statistics, it is important that these should be correct; and there is no reason why the Offices should rest contented with imperfect data, when their own books can supply them accurately, and in the greatest abundance; and if some experienced members of the profession could be induced to co-operate in arranging a comprehensive and simple classification of risks, the individual Offices or such of them as approved of the idea might analyze their own business in conformity with that model; and were it thought advisable, their united statistics might be collected for the benefit of the profession generally.

Continuation of a Paper on a Method of Distributing the Surplus among the Assured in a Life Assurance Company. *By* T. B. SPRAGUE, M.A., *Fellow of St. John's College, Cambridge.*

IN the present paper I propose to give some numerical illustrations of the working of the method of which the formulæ were given in the last Number of this *Magazine*, and to add some further results which have been subsequently arrived at.